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Morrow et al.

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(54) **FLEXIBLE CIRCUIT SEAL**

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(51) **Int. Cl.**

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B41J 2/16	(2006.01)
B41J 2/14	(2006.01)

(52) **U.S. Cl.**

CPC ***B41J 2/1623*** (2013.01); ***B41J 2/1607*** (2013.01); *B41J 2002/14362* (2013.01); ***B41J 2/14024*** (2013.01); ***B41J 2/14201*** (2013.01); ***B41J 2/1601*** (2013.01)

(58) **Field of Classification Search**

CPC B41J 2/1623; B41J 2/14024; B41J 2002/14362

USPC 347/54–59

See application file for complete search history.

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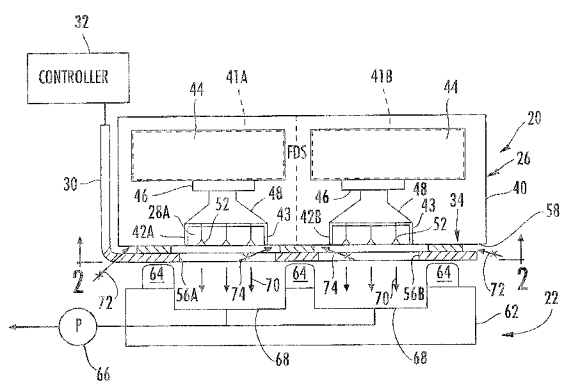
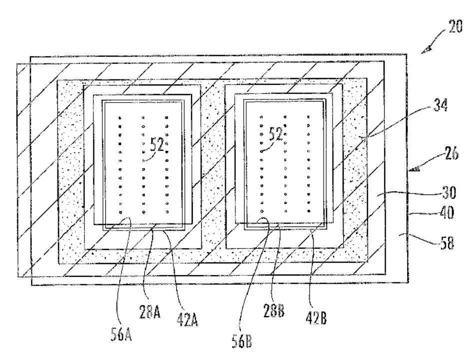
Primary Examiner — Daniel Petkovsek

(57) **ABSTRACT**

Various embodiments and methods relating to an adhesive paste layer (**34**, **134**) sandwiched between a flexible circuit (**30**) and a fluid delivery system (**26**) to form a seal at least partially about a print head (**28**) are disclosed.

25 Claims, 9 Drawing Sheets





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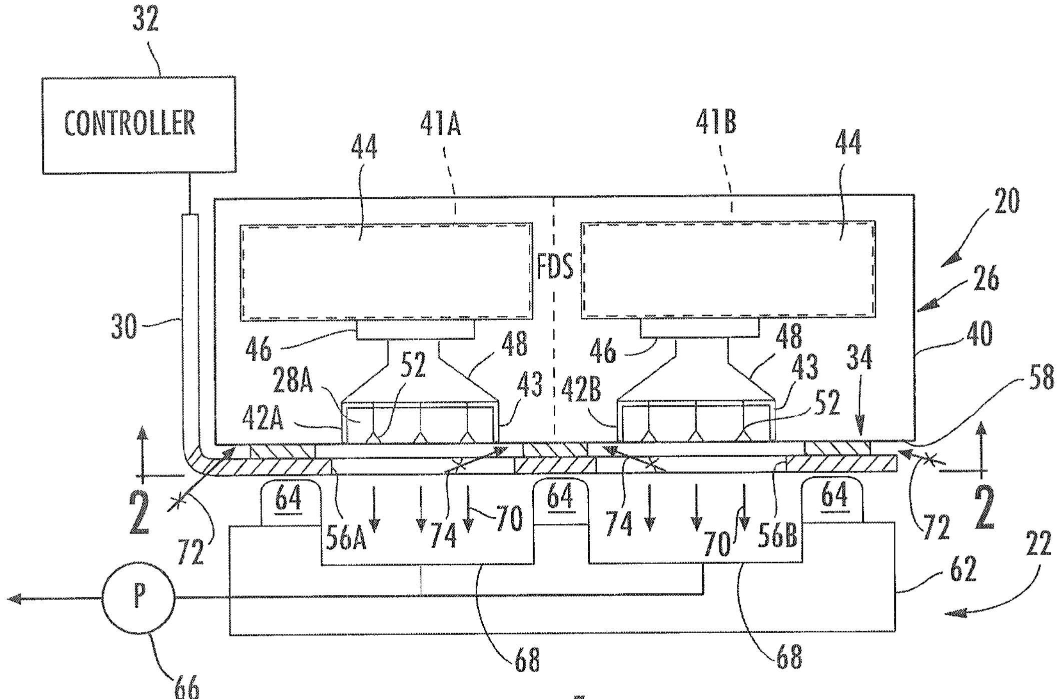
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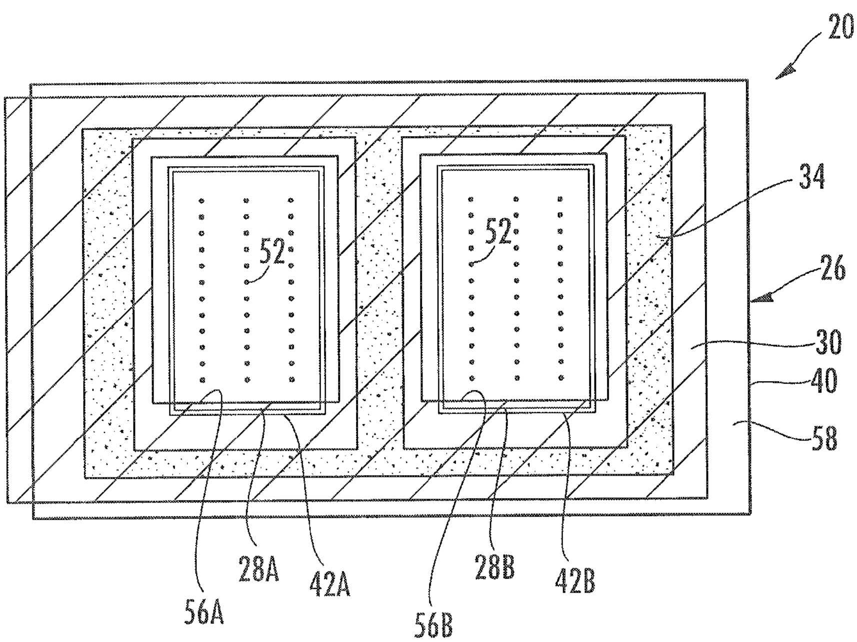
CONTROLLER
41A
41B
44
44
20
FDS
26
30
40
46
48
46
48
52
43
43
34
58
28A
42B
42A
52
2
2
64
64
64
56A
74
70
74
70
56B
72
72
22
P
62
66
68
68

FIG. 1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34
52
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26
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58
56A
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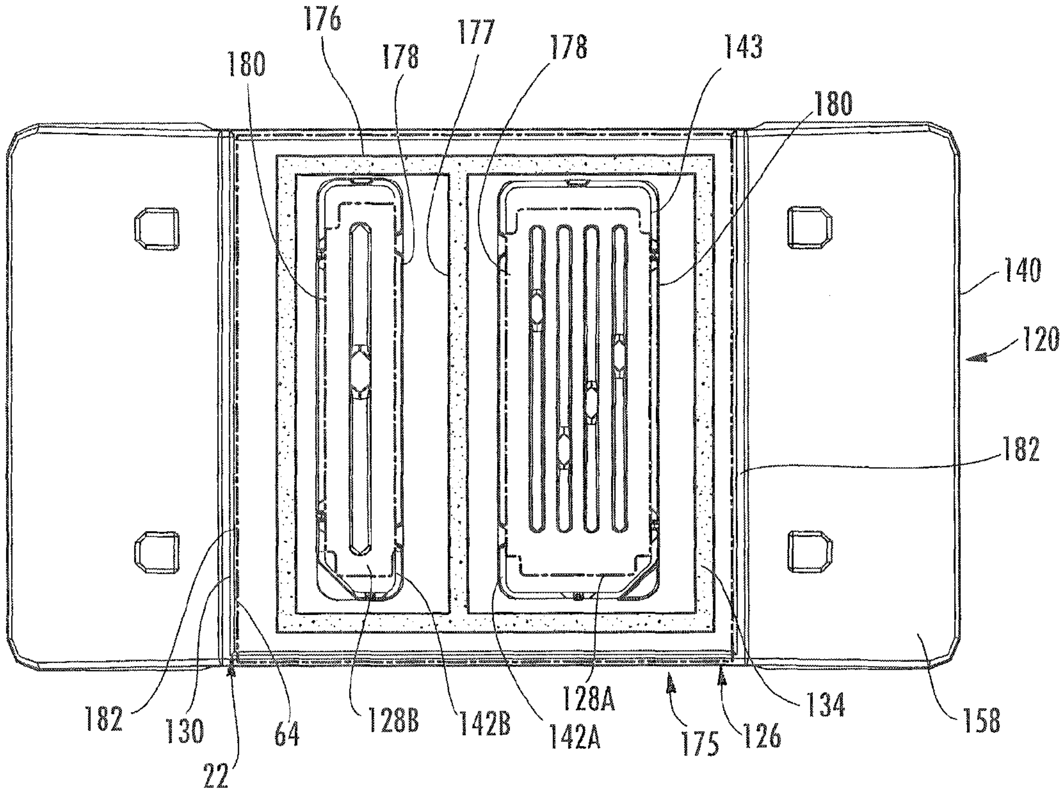
42A
56B
28B
42B

FIG. 2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143
180
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64
22
128B
142B
142A
128A
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134
158

FIG. 3

FIG. 4

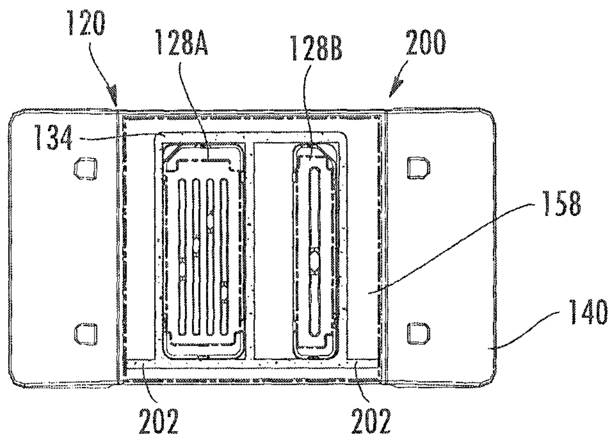


FIG. 5

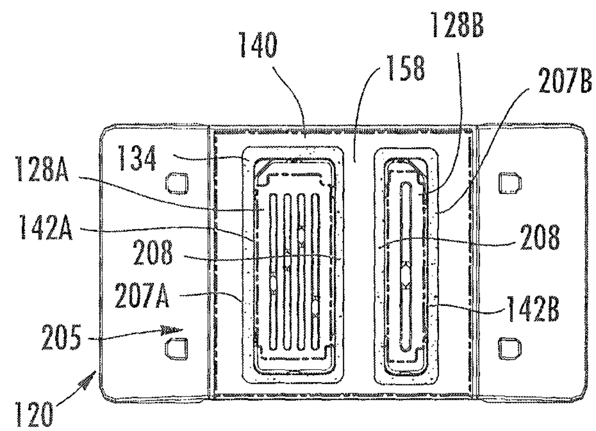


FIG. 6

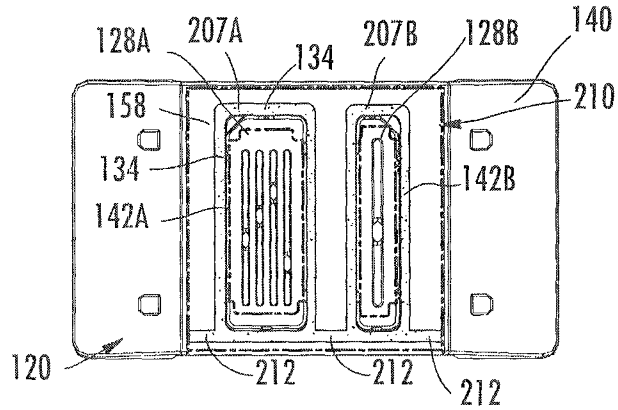


FIG. 7

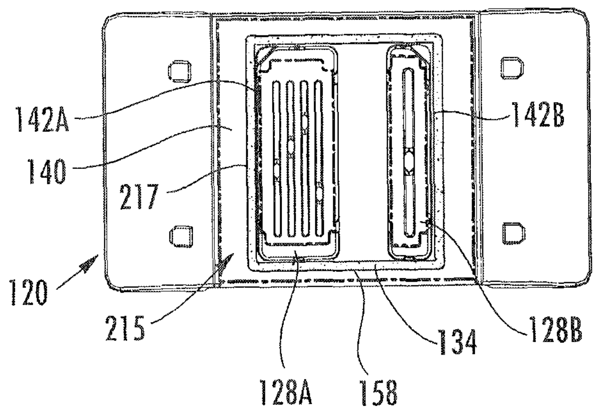


FIG. 8

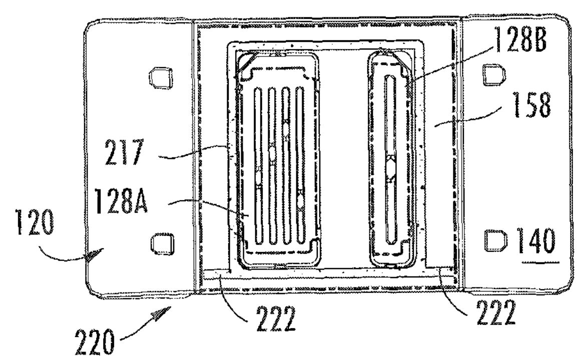


FIG. 9

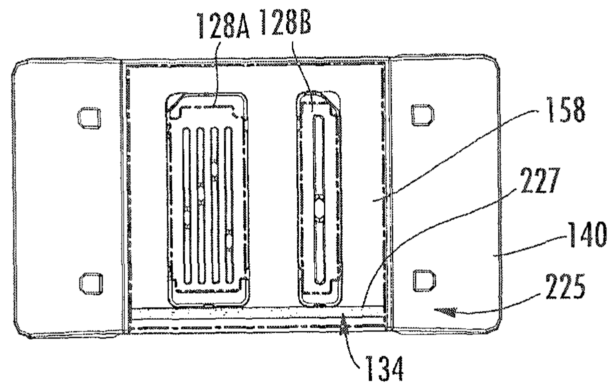


FIG. 10

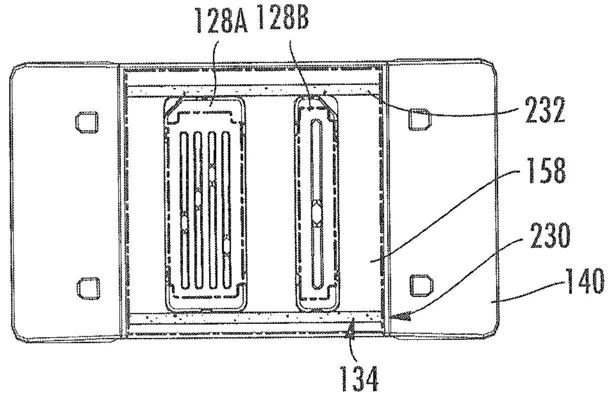


FIG. 11

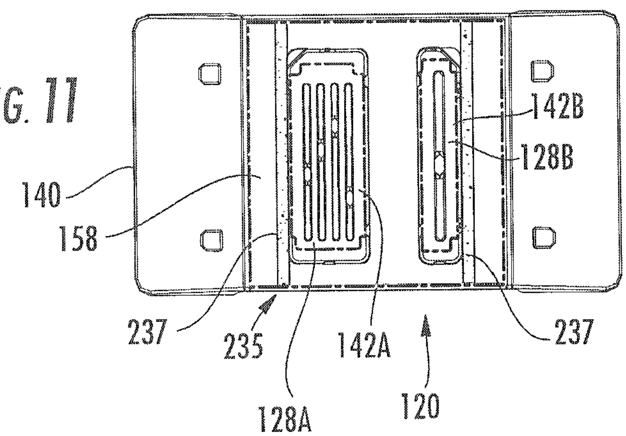
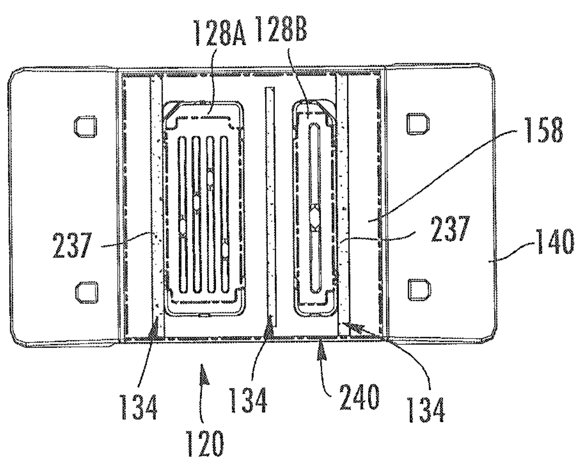


FIG. 12



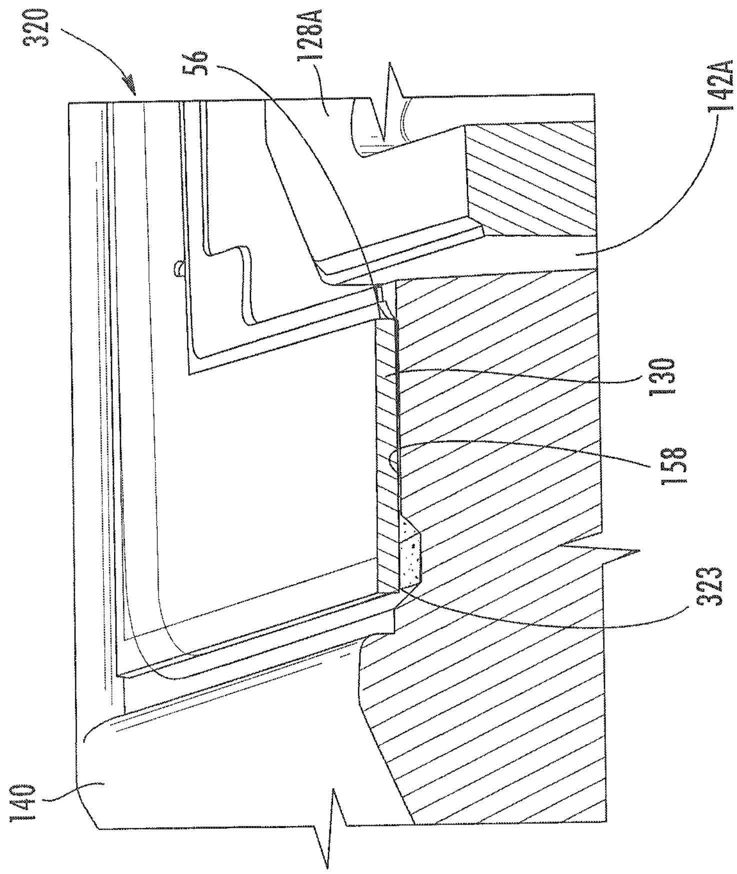


FIG. 15

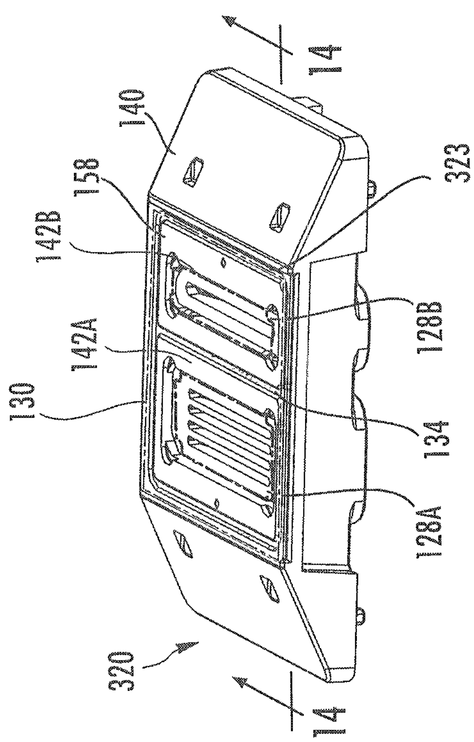


FIG. 13

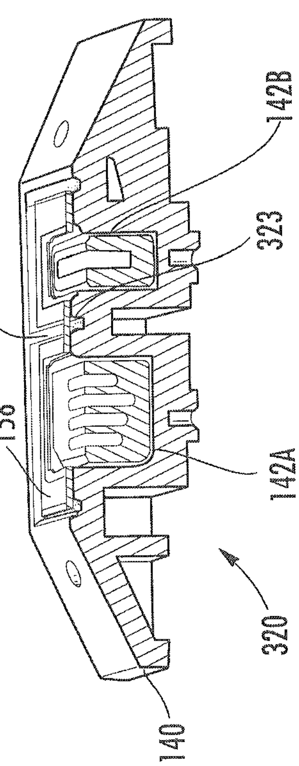


FIG. 14

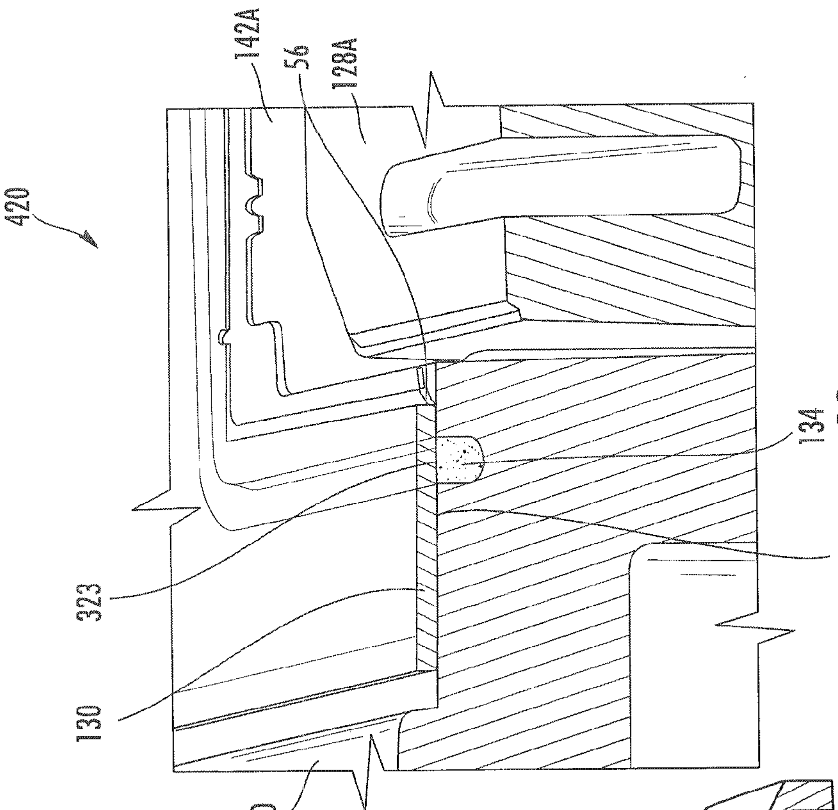


FIG. 18

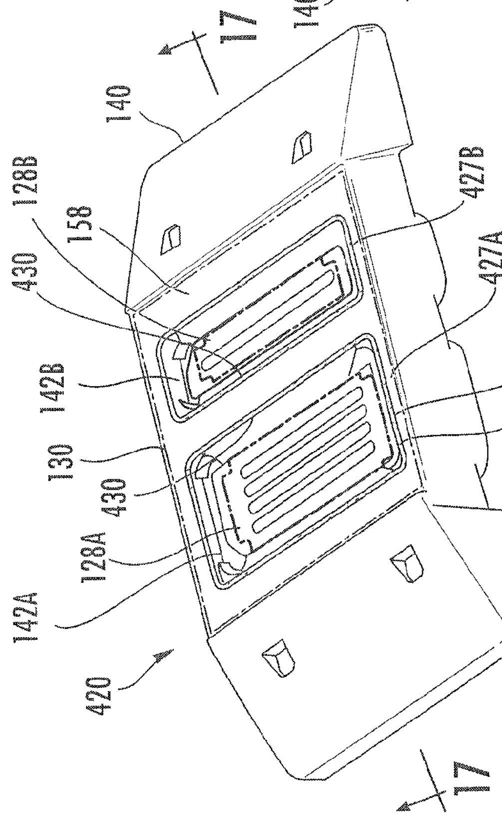


FIG. 16

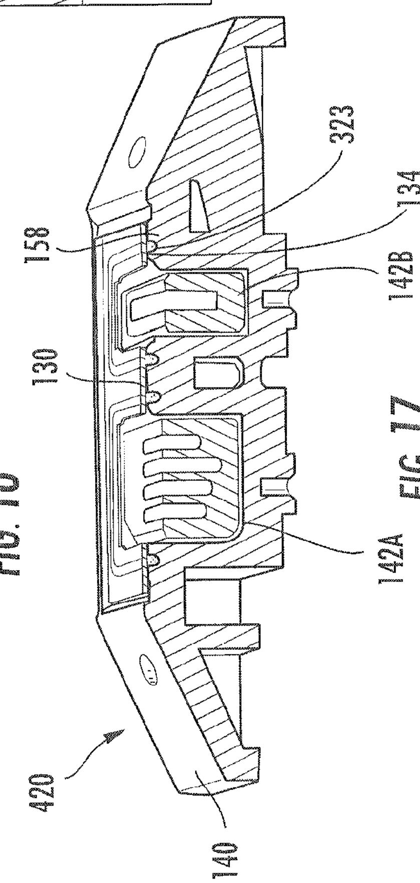


FIG. 17

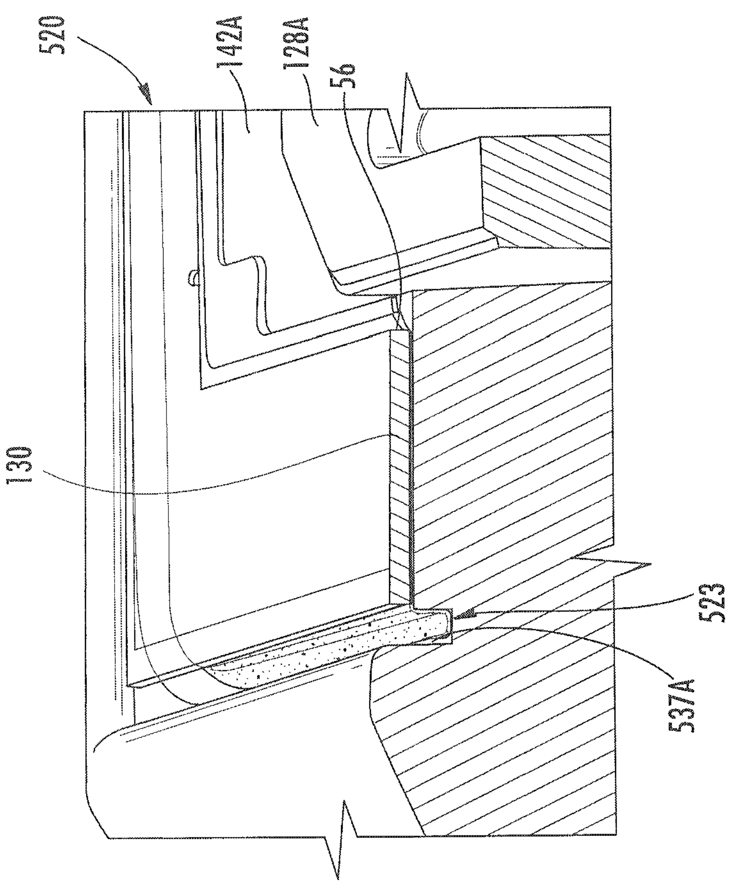


FIG. 21

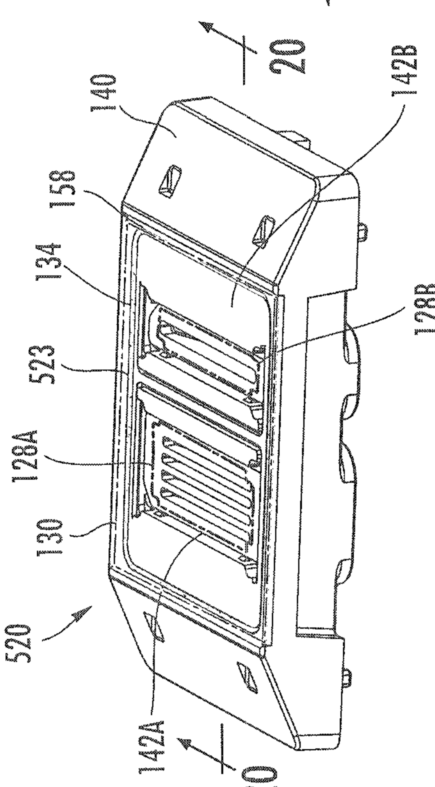


FIG. 19

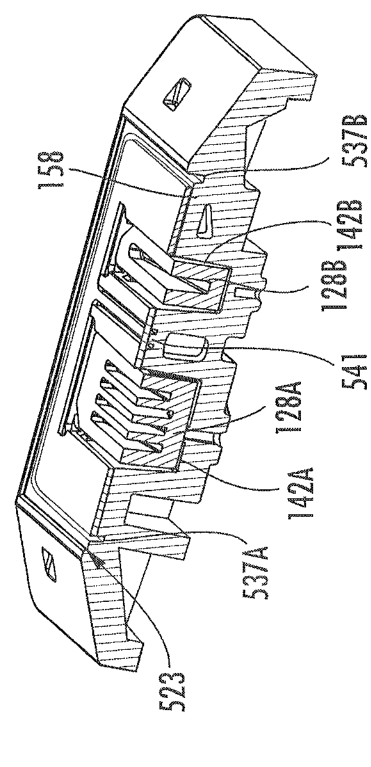


FIG. 20

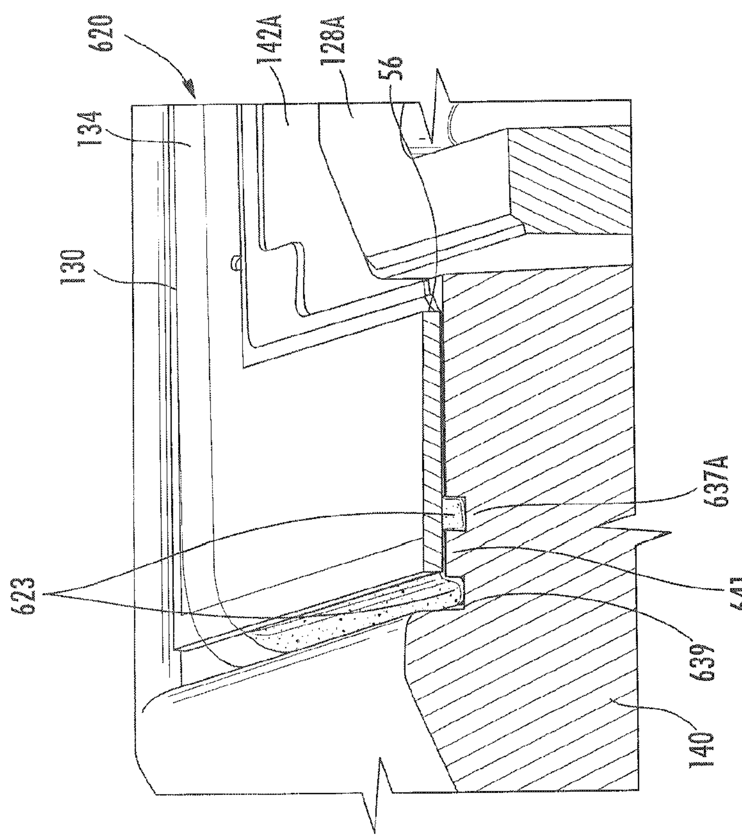


FIG. 24

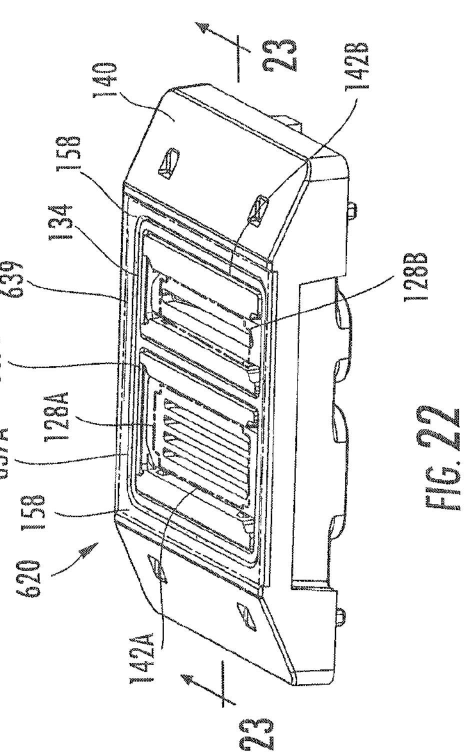


FIG. 22

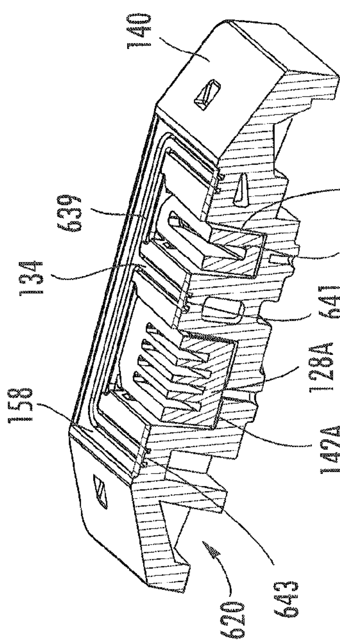


FIG. 23

FLEXIBLE CIRCUIT SEAL

BACKGROUND

During print head priming, a vacuum is created to draw fluid through nozzles of the print head. Leaks to atmosphere may impair such priming. Fluid communication between adjacent print heads may also lead to cross-contamination.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sectional view of schematically illustrating priming of a printing device according to an example embodiment.

FIG. **2** is a sectional view of the printing device of FIG. **1** taken along line **2-2** according to an example embodiment.

FIG. **3** is a bottom plan view of another embodiment of the printing device of FIG. **1** illustrating relative positioning of a sealing zone during priming according to an example embodiment.

FIGS. **4-12** are bottom plan view the illustrating various patterns for a solidified adhesive paste layer of the printing device of FIG. **3** according to an example embodiment.

FIG. **13** is a top perspective view of another embodiment of the printing device of FIG. **3** according to an example embodiment.

FIG. **14** is a sectional view of the printing device of FIG. **13** taken along line **14-14** according to an example embodiment.

FIG. **15** is an enlarged view of a portion of the printing device of FIG. **14** according to an example embodiment.

FIG. **16** is a top perspective view of another embodiment of the printing device of FIG. **3** according to an example embodiment.

FIG. **17** is a sectional view of the printing device of FIG. **16** taken along line **17-17** according to an example embodiment.

FIG. **18** is an enlarged view of a portion of the printing device of FIG. **17** according to an example embodiment.

FIG. **19** is a top perspective view of another embodiment of the printing device of FIG. **3** according to an example embodiment.

FIG. **20** is a sectional view of the printing device of FIG. **19** taken along line **20-20** according to an example embodiment.

FIG. **21** is an enlarged view of a portion of the printing device of FIG. **20** according to an example embodiment.

FIG. **22** is a top perspective view of another embodiment of the printing device of FIG. **3** according to an example embodiment.

FIG. **23** is a sectional view of the printing device of FIG. **22** taken along line **22-22** according to an example embodiment.

FIG. **24** is an enlarged view of a portion of the printing device of FIG. **22** according to an example embodiment.

DETAILED DESCRIPTION OF THE EXAMPLE EMBODIMENTS

FIGS. **1** and **2** schematically illustrate printing device **20** according to an example embodiment. FIG. **1** further illustrates priming device **22** priming and servicing printing device **20**. As will be described hereafter, printing device **20** is configured to reduce leakage during priming to enhance effectiveness of priming and to reduce cross-contamination.

As shown by FIG. **1**, printing device **20** includes fluid delivery system **26**, print heads **28**A, **28**B (collectively referred to as print heads **28**), flexible circuit **30**, controller **32** and solidified adhesive paste layer **34**. Fluid delivery system **26** comprises a mechanism configured to supply and deliver fluid, such as ink, to print heads **28**. Fluid delivery system **26**

includes a body **40**, back pressure regulation mechanisms **44**, filters **46** and standpipes **48**. Body **40** comprises one or more structures configured to contain fluid. In one embodiment, body **40** may comprise a self-contained reservoir of fluid. In another embodiment, body **40** may receive fluid from a remote fluid supply or may circulate fluid to and across print heads **28**.

In the embodiment illustrated, body **40** includes isolated internal chambers **41**A and **41**B (collectively referred to as chambers **41**) for supplying distinct fluids to print heads **28**A and **28**B, respectively. For example, in one embodiment, a first color of ink may be supplied to print head **28**A while a second distinct color of ink is applied to print head **28**B. For purposes of this disclosure, with reference to inks, the term "color" includes black inks. In other embodiment, body **40** may include greater or fewer of such isolated chambers.

In the example illustrated in FIG. **1**, body **40** includes pockets **42**A and **42**B (collectively referred to as pockets **42**). Pockets **42** comprise recesses or cavities formed in a lower side of body **40** configured to receive print heads **28**. Due to clearances between pockets **42** and print heads **28**, pockets **42** form gaps or moats **43** between print heads **28** and body **40**. Although body **40** is illustrated as including two such pockets, in other embodiments, body **40** may include a greater or fewer of such pockets **42**.

Back pressure regulation mechanisms **44** (schematically shown) comprise mechanisms configured to provide a controlled extent of back pressure so as to reduce the likelihood of fluid drooling through print heads **28**. Examples of back pressure regulation mechanisms **44** include, but are not limited to, inflatable bags, foam or other capillary members. Filters **46** extend between mechanisms **44** and standpipes **48** to filter fluid prior to entering standpipes **48**. Standpipes **48** comprise fluid passages including one or more slots for directing fluid to print heads **28**. In other embodiments, fluid delivery system **26** may include other mechanisms for delivering fluid to print heads **28** and may omit one or more of back pressure regulation mechanisms **44**, filters **46** and standpipes **48**.

Print heads **28** comprise mechanisms to selectively eject fluid, such as ink, onto a print medium in response to control signal received from controller **32**. In one embodiment, print heads **28** may comprise thermoresistive drop-on-demand inkjet print heads. In another embodiment, print heads **28** may comprise piezo resistive drop-on-demand inkjet print heads. Print heads **28** each include a series or array of openings or nozzles **52** configured to receive fluid from fluid delivery system **26**. In the example illustrated, nozzles **52** of print heads **28** are in fluid communication with standpipes **48**.

In the particular example illustrated, print head **28**A is in fluid communication with chamber **41**A so as to selectively eject a first type of fluid. Print head **26**B is in fluid communication with chamber **41**B so as to selectively eject a second distinct type of fluid. In other embodiments, printing device **20** may include a greater or fewer of such print heads **28**.

Flexible circuit **30** comprises a series or array of electrical circuits encased in a dielectric material, such as a polymeric encasement. In one embodiment, the polymeric encasement comprises one or more polyamides. Flexible circuit extends from controller **32** to print heads **28**. As shown by FIG. **2**, flexible circuit **30** includes openings **56**A and **56**B (collectively referred to as openings **56**) such that flexible circuit **30** extends completely about or around pockets **42** and print heads **28** on all sides of print heads **28**. Openings **56**A and **56**B are in substantial alignment with pocket **42**A and with pocket **42**B, as well as print head **28**A and print head **28**B, respectively.

As shown by FIG. **2**, in the example illustrated, a portion of flexible circuit **30** slightly extends beneath or underlies a small portion of print heads **28**, facilitating connection between flexible circuit **30** and print heads **28**. Flexible circuit **30** bends and wraps about fluid delivery system **26**, extends towards controller **32** and is coupled to or retained along a side of body **40** so as to not interfere with printing upon the print media. Flexible circuit **30** facilitates facilitate communication between print heads **28** and controller **32**.

In other embodiments, flexible circuit **30** may have other configurations. For example, in other embodiments, flexible circuit **30** may openings **56** having different shapes and different relative locations. In other embodiments, flexible circuit **30** may merely include a single opening **56** or may include greater than two openings **56**. In other embodiments, flexible circuit **30** may not extend completely about and on all sides of print heads **28**.

Controller **32** comprises one or more processing units coupled to print heads **28** by flexible circuit **30**. For purposes of this application, the term "processing unit" shall mean a presently developed or future developed processing unit that executes sequences of instructions contained in a memory. Execution of the sequences of instructions causes the processing unit to perform steps such as generating control signals. The instructions may be loaded in a random access memory (RAM) for execution by the processing unit from a read only memory (ROM), a mass storage device, or some other persistent storage. In other embodiments, hard wired circuitry may be used in place of or in combination with software instructions to implement the functions described. For example, controller **32** may be embodied as part of one or more application-specific integrated circuits (ASICs). Unless otherwise specifically noted, the controller is not limited to any specific combination of hardware circuitry and software, nor to any particular source for the instructions executed by the processing unit. Controller **32** generates control signals which are transmitted by flexible circuit **30** to print heads **28**. The control signals cause print heads **28** to selectively eject fluid through selected nozzles **52** in a controlled fashion.

Solidified adhesive paste layer **34** comprises a layer or bead of solidified adhesive paste sandwiched between flexible circuit **30** and a lower surface or face **58** of body **40** at least partially about a perimeter of one or both of print heads **28**. Solidified adhesive paste layer **34** has sufficiently low viscosity, prior to curing or solidification, such that the adhesive paste may flow into or wet gaps or voids in surface **58** as well as along the exterior of flexible circuit **30**. In addition, layer **34** also accommodates surface irregularities or non-flatness associated with surface **58**. As a result, upon curing or other solidification, the adhesive paste of layer **34** forms a hermetic seal between surface **58** and the opposing portion of flexible circuit **30**. The seal formed by layer **34** between surface **58** of body **40** and flexible circuit **30** inhibits airflow or fluid flow between flexible circuit **30** and body **40**. Consequently, priming is enhanced and cross-contamination of different fluids between print heads **28** is reduced.

In the example illustrated, the adhesive paste material of layer **34** has a sufficiently low viscosity so as to readily flow into the gaps or voids a long surface **58** and along flexible circuit **30**. In one embodiment, the adhesive paste material has a viscosity at room temperature of less than or equal to about 200,000 centipoise (cp). In one embodiment, the adhesive paste material a layer **34** comprises an epoxy paste. In one embodiment, adhesive paste layer **34** comprises a 1 part epoxy paste (does not need mixing, but utilizes a curing process step). In one embodiment, adhesive paste layer **34** comprises Bisphenol A thermosetting epoxy. In other embodiments, other types of adhesive pastes may be used.

Adhesive paste layer **34** may be formed between flexible circuit **30** and surface **58** of body **40** in various manners. In one embodiment, adhesive paste material of layer **34** may be initially deposited upon flexible circuit **30**, wherein flexible circuit **30** is then pressed against surface **58**, bringing layer **34** into contact with surface **58**. In another embodiment, adhesive paste material of layer **34** may be initially deposited upon surface **58**, wherein flexible circuit **30** is pressed into contact with the adhesive paste material of layer **34** on surface **58**.

The adhesive paste material of layer **34** may be applied on one or both of flexible circuit **30** and surface **58** by various techniques including, but not limited to, robot needle dispensing, showerhead dispensing, manual needle dispensing, silk screening, or patterned preforms. With patterned preforms, the adhesive paste material may be in a non-paste state upon both sides of the preform, wherein the preform is treated, such as with the application of heat, so as to cause the adhesive paste material on the preform or backing to change to a paste state. Once in the paste state, the adhesive paste material on the preform may be pressed into contact with either surface **58** or flexible circuit **30** prior to being joined to the other of surface **58** or flexible circuit **30**.

As shown by FIG. **2**, solidified adhesive paste layer **34** extends at least partially about a perimeter of each of print heads **28**. In the example illustrated, layer **34** continuously extends about both of print heads **28**, collectively, while being sandwiched between surface **58** and circuit **30**. As a result, layer **34** forms a continuous seal between circuit **30** and surface **58** about both of print heads **28**.

As further shown by FIG. **2**, solidified adhesive paste layer **34** also continuously extends between print heads **28** while being sandwiched between surface **58** and circuit **30**. Layer **34** also forms a continuous uninterrupted wall between print heads **28** to isolate print heads **28**A and **28**B from one another. As a result, layer **34** also inhibits the flow of fluid, such as ink, between circuit **30** and surface **58** from one of print heads **28** to another of print heads **28** to reduce or eliminate cross-contamination during priming.

FIG. **1** schematically illustrates priming using priming device **22**. Priming device **22** includes cap **62**, sealing members **64** and pump **66**. Cap **62** comprises structure forming basins **68**. Basins **68** provide volumes configured to be positioned opposite to print heads **28** so as to receive fluid drawn through nozzles **52** during priming of nozzles **52**.

Sealing members **64** comprise structures configured to seal against printing device **20**. In the example illustrated, sealing members **64** seal against an underside of flexible circuit **30** or seal against those portions of surface **58** not covered by circuit **30** to prevent fluid flow between members **64** and flexible circuit **30** or to prevent fluid flow between members **64** and surface **58** during priming. In one embodiment, sealing members **64** comprises elastomeric or compressible rings or gaskets of material configured to deform or compress when forming a seal against circuit **30** or portions of surface **58**.

Pump **66** comprises a fluid pump include communication with basins **68**. Pump **66** is configured to draw or pump air from basins **68** so as to create a vacuum in basins **68** against print heads **28**. In one embodiment, pump **66** may comprise a peristaltic pump. In other embodiments, pump **66** may have other configurations.

As schematically represented by arrows **70**, the vacuum created in basins **68** by pump **66** draws fluid through nozzles **52** of print heads **28** into basins **68** to prime print heads **68**. The withdrawn fluid is subsequently removed from basins **68** by pump **66**. As schematically represented by crossed out arrows **72**, the vacuum created in basins **68** may also attempt to draw air between any gaps that may exist between flexible circuit **30** and surface **58** of body **40**. However, solidified adhesive paste layer **34** fills any such avoids or irregularities and inhibits leakage of air into basins **68**. As a result, priming performance is enhanced.

At the same time, as schematically represented by crossed out arrows **74**, the vacuums created within basins **68** may also tend to draw ejected fluid between surface **58** and flexible circuit **30** between print heads **28**. However, solidified adhesive paste layer **34** fills any voids or cavities that may exist between circuit **30** and surface **58** between print heads **28** to prevent such fluid flow. As a result, layer **34** reduces or prevents cross-contamination of different types of fluid, such as different colors of ink.

FIG. **3** illustrates printing device **120**, a particular embodiment of printing device **20**, with portions omitted for purposes of illustration. As shown by FIG. **3**, printing device **120** includes fluid delivery system **126**, print heads **128**A, **128**B (collectively referred to as print heads **128**), flexible circuit **130**, controller **32** (shown in FIG. **1**) and solidified adhesive paste layer **134**. Fluid delivery system **126**, print heads **128** and flexible circuit **130** are substantially identical to fluid delivery system **26**, print heads **28** and flexible circuit **30** shown and described with respect to FIGS. **1** and **2**. For purposes of illustration, print heads **128** are illustrated without an overlying nozzle plate to better illustrate pockets **142**A and **142**B receiving and extending about print heads **128**A and **128**B, respectively. In the particular example illustrated in FIG. **3**, print heads **128**A and **128**B have slightly different configurations as compared to print heads **28**A and **28**B which are schematically shown in FIGS. **1** and **2**.

As further shown by FIG. **3**, solidified adhesive paste layer **134** comprises a layer or bead of solidified adhesive paste sandwiched between flexible circuit **130** and a lower surface or face **158** of body **140** about both of print heads **128**. Solidified adhesive paste layer **34** has sufficiently low viscosity, prior to solidification, such that the adhesive paste may flow into or wet gaps or voids in surface **158** as well as along the exterior of flexible circuit **130**. In addition, layer **134** also accommodates surface irregularities or non-flatness associated with surface **158**. As a result, upon curing or other solidification, the adhesive paste of layer **134** forms a hermetic seal between surface **158** and the opposing portion of flexible circuit **130**. In particular embodiments, the adhesive paste material of layer number **134** may only partially solidify, wherein the final layer **134** has a sufficiently high viscosity to maintain its integrity during priming. The seal formed by layer **134** between surface **158** of body **140** and flexible circuit **130** inhibits airflow or fluid flow between flexible circuit **130** and body **140**. Consequently, priming is enhanced and cross-contamination of different fluids between print heads **128** is reduced.

In the example illustrated, the adhesive paste material of layer **134** has a sufficiently low viscosity so as to readily flow into the gaps or voids along surface **158** and along flexible circuit **130**. In one embodiment, adhesive paste material has a viscosity at room temperature of less than or equal to about 200,000 centipoise (cp). In one embodiment, the adhesive paste material a layer **134** a 1 part epoxy paste (does not need mixing, but utilizes a curing process step). In one embodiment, adhesive paste layer **134** comprises Bisphenol A thermosetting epoxy. In other embodiments, other types of adhesive pastes may be used.

Adhesive paste layer **134** may be formed between flexible circuit **130** and surface **158** of body **140** in various manners. In one embodiment, adhesive paste material of layer **134** may be initially deposit upon flexible circuit **130**, wherein flexible circuit **130** is then pressed against surface **158**, bringing layer **134** into contact with surface **158**. In another embodiment, adhesive paste material of layer **134** may be initially deposit upon surface **158**, wherein flexible circuit **130** is pressed into contact with the adhesive paste material of layer **134** on surface **158**.

The adhesive paste material of layer **134** may be applied on one or both of flexible circuit **130** and surface **158** by various techniques including, but not limited to, robot needle dispensing, showerhead dispensing, manual needle dispensing, silk screening, or patterned preforms. With patterned preforms, the adhesive paste material may be in a non-paste state upon the preforms, wherein the preform is treated, such as with the application of heat, so as to cause the adhesive paste material on both sides of the preform or backing to change to a paste state. Once in the paste state, the adhesive paste material on the preform may be pressed into contact with either surface **158** or flexible circuit **130** prior to being joined to the other of surface **58** or flexible circuit **30**.

FIG. **3** illustrates one example pattern **175** for layer **134**. With pattern **175**, layer **134** continuously extends about both of print heads **128**, collectively, while being sandwiched between surface **158** and circuit **130**. As a result, layer **134** forms a continuous seal between circuit **130** and surface **158** about both of print heads **128**.

With pattern **175**, solidified adhesive paste layer **'134** also continuously extends between print heads **'128** while being sandwiched between surface **'158** and circuit **'130**. Pattern **175** includes a loop **176** continuously extending about both print heads **128** and a segment **177** extending between printheads **128** and interconnecting opposite sides of look **176**. Layer **'134** forms a continuous wall between print heads **128** to isolate print heads **128**A and **128**B from one another. As a result, layer **134** also inhibits the flow of fluid, such as ink, between circuit **130** and surface **158** from one of print heads **128** to another of print heads **128** to reduce or eliminate cross-contamination during priming.

FIG. **3** further illustrates the position of priming device **22** (described above with respect to FIG. **1**) with respect to printing device **120** during priming to form a sealing zone. In particular, FIG. **3** illustrates the relative positioning of sealing members **64** during priming. As shown by FIG. **3**, solidified adhesive paste layer **134** is formed between flexible circuit **130** and surface **158** of body **140** such that layer **134** is centrally located midway or equidistantly between the inner edges **178** of pockets **142**. Layer **134** is also located midway between or equidistantly between the outer edges **180** of such pockets **142** and outboard edges **182** of flexible circuit **130**. Because layer **134** is located midway between such edges, adhesive layer **134** is less likely to squeeze out into moats **143** and into pockets **142** where such adhesive paste may become deposited excessively close to the dies of print heads **128** so as to potentially interfere with wiping and impose strains upon the print head dies. Moreover, those portions of flexible circuit **130** overlying layer **134** are directly opposite to the nominal location or extent of sealing members **64** of priming device **22**. As a result, sealing members **64** may better seal against the portion of the flexible circuit **130** rigidified by layer **134**.

In other embodiments, adhesive layer **134** may be positioned or formed at other locations relative to edges **178**, **180** and **182**. For example, in other embodiments, portions of layer **134** may alternatively be formed proximate to or even along edges **182** or more proximate to and along edges **180**. That portion of layer **134** extending between print heads **128** may alternatively extend or proximate to or even adjacent to edge **178** of the print head **128**A or edge **178** of print head **128**B. Even with such alternative embodiments, reduced leakage and reduced cross-contamination may be achieved.

FIGS. **4-13** illustrate other alternative patterns for solidified adhesive paste layer **134**. FIG. **4** illustrates pattern **200** for solidified adhesive paste layer **134**. Pattern **200** is similar to pattern **175** except that pattern **180** extends closer to edge **178** of print head **128**A and additionally includes segments **202**. Segments **202** provide additional adhesive areas for securing flexible circuit **130** to body **140**. As a result, flexible circuit **130** is more securely retained along body **140**.

FIG. **5** illustrates pattern **205** for solidified adhesive paste layer **134**. As shown by FIG. **5**, with pattern **205**, adhesive paste layer **134** comprises two continuous uninterrupted loops **207**A, **207**B continuously extending about an entire perimeter of each of print heads **128**A and **128**B, respectively. Although loops **207** are illustrated as being relatively close to print heads **128**, in other embodiments, loops **207** may be more greatly spaced from edges of print heads **128** and their associated pockets **142**. With pattern **205**, two walls **208** are provided between print heads **128**, adding isolation between print heads **128** to reduce cross-contamination.

FIG. **6** illustrates pattern **210** of solidified adhesive paste layer **134**. Pattern **210** is similar to pattern **205** except that pattern **210** additionally includes segments **212**. Segments **212** provide enhanced securement of flexible circuit **130** (shown in FIG. **3**) relative to surface **158**.

FIG. **7** illustrates pattern **215** of solidified adhesive paste layer **134**. Pattern **215** is similar to pattern **175** except that pattern **215** comprises a single loop **217** extending continuously and entirely about both print heads **128** without extending between print heads **128**. Pattern **215** provides a lesser degree of isolation between print heads **128**, but may be easier to apply and may be beneficial in embodiments where print heads **128** are extremely close to one another.

FIG. **8** illustrates pattern **220** of solidified adhesive paste layer **134**. Pattern **220** is similar to pattern **215** except that pattern **220** additionally includes segments **222**. Segments **222** provide enhanced securement of flexible circuit **130** (shown in FIG. **3**) relative to surface **158**.

FIGS. **9-12** illustrate various other patterns of adhesive paste layer **134**, wherein layer **134** does not completely surround one or both of print heads **128**, but alternatively extends along one or more sides of print heads **128**. FIG. **9** illustrates pattern **225** in which layer **134** comprises a single segment or line **227** extending across the shorter side of print heads **128**. FIG. **10** illustrates pattern **230**. Pattern **230** is similar to pattern **225** except that pattern **230** includes an additional line **232** on an opposite side of print heads **128**. Patterns **225** and **230** may reduce leakage along particular sides of print heads **128** and may provide enhanced securement of flexible circuit **130** (shown in FIG. **3**) as compared to a printing device **120** omitting layer **134**.

FIG. **11** illustrates pattern **235** of solidified adhesive paste layer **134**. Pattern **235** includes a pair of opposing segments or lines **237** extending on the longer sides of print heads **128** along opposite side to apprentice **128**. Lines **237** may reduce leakage along particular sides of print heads **128** and may provide enhanced securement of flexible circuit **130** (shown in FIG. **3**) as compared to a printing device **120** omitting layer **134**.

FIG. **12** illustrates pattern **240** of solidified adhesive paste layer **134**. Pattern **240** is similar to pattern **235** except that pattern **240** additionally includes segment or line **242**. Line **242** extends between print heads **128**. Line **242** provides additional isolation between print heads **128** to reduce likelihood of cross contamination.

FIGS. **13-15** illustrate printing device **320**, another embodiment of printing devices **20** and **120**. Printing device **320** is similar to printing device **120** with pattern **175** of solidified adhesive paste layer **134** except that surface **158** of body **140** of fluid delivery system **126** includes a depression, groove, channel or trench **323** extending into surface **158**. As shown by FIG. **13**, trench **323** has the same pattern as that of solidified adhesive paste layer **134**. In the example illustrated, trench **323** continuously extends about print heads **128** and between print heads **128**. In other embodiments wherein layer **134** has other patterns, such as those shown in FIGS. **4-12**, trench **323** may also have corresponding patterns.

As shown by FIGS. **14** and **15**, trench **323** receives solidified adhesive paste layer **134**. Trench **323** limits or contains extent to which the adhesive paste material of layer **134** may migrate prior to partial or complete solidification. Trench **323** further provides flexible circuit **130** with a greater degree of flatness or levelness. In particular, the material of adhesive paste layer **134** (prior to solidification) is directly deposited into trench **323** to a height at, just above or proximate to surface **158** so as to contact and seal against flexible circuit **130**. As a result, trench **323** enables a greater volume of the adhesive paste material layer **34** to be applied without a corresponding unevenness of flexible circuit **130** being created. Flexible circuit **130** may have a greater degree of parallelism with surface **158**. As a result, trench **323** may enhance subsequent sealing against flexible circuit **130** during priming and may permit printing device **320** to be positioned closer to media during printing.

According to one example embodiment, trench **323** has a width of between about 0.25 mm and about 2 mm (nominally about 0.5 mm) and a depth of between about 0.1 mm and about 2 mm (nominally about 0.25 mm). In other embodiments, trench **323** may have other widths or depths depending upon the desired amount of adhesive paste material that is to be used to form layer **134**.

FIG. **16-18** illustrate printing device **420** another embodiment of printing devices **20** and **120**. Printing device **420** is similar to printing device **320** except that solidified adhesive paste layer **134** and trenches **323** each have pattern **205** as shown and described above with respect to FIG. **5**. As shown by FIG. **16**, trenches **323** comprise two distinct loops **427**A and **427**B (collectively referred to as loops **427**). Loop **327**A continuously extends about print head **128**A. Loop **427** continuously extends about print head **128**B. As before, trenches **323** directly receive adhesive paste material of layer **134**. Trenches **323** serve to contain the adhesive paste material as it cures or solidifies. As noted above, trench **323** further enhances flatness of flexible circuit **130**. Because trenches **323** and layer **134** form two independent isolation walls **430** between print heads **128**, enhanced isolation of print heads **128** is provided which may reduce cross-contamination during priming.

FIGS. **19-21** illustrate printing device **520**, another embodiment of printing devices **20** and **120**. Printing device **520** is similar to printing device **320** with solidified adhesive paste layer **134** having pattern **175** except that printing device **520** additionally includes impressions, grooves, channels or trenches **523**. Trenches **523** extend into surface **158** on one or both sides of layer **134**. Trenches **523** serve as overflow channels or gutters by receiving excess adhesive paste material of layer **134** as flexible circuit **130** and surface **158** are being pressed against one another prior to curing or solidification of the adhesive paste material of layer **134**. In such an embodiment, the material of adhesive paste layer **134** (prior to solidification) is deposited directly upon surface **158** near trenches **523**. Excess material of layer **134** is squeezed into trenches

523. As a result, trenches **523** serve to contain the extent to which the adhesive paste material may migrate along surface **158** prior to solidification. Trenches **523** further receive excess adhesive paste material, reducing unevenness of flexible circuit **130** and enhancing the degree of flatness of flexible circuit **130** to potentially improve the ability of priming device **22** (shown in FIG. **1**) to form a seal against flexible circuit **130**.

In the example illustrated, trenches **532** form two distinct loops **537**A and **537**B (collectively referred to as loops **537**). Those portions of loops **537** between print heads **128** form an intermediate plateau, rib or landing **541**. In the example illustrated, the portion of layer **134** extending between print heads **128** is a largely centered on landing **541**. As a result, layer **134** between print heads **128** is contained in both directions by trenches **523**. Thus, layer **134** may be provided in closer proximity to one or both print heads **128** with a reduced likelihood of layer **134** interfering with or affecting the performance of print heads **128**. This allows print is **128** to also be positioned closer to one another for a more compact design. At the same time, layer **134** continues to provide enhanced isolation between print heads **128** to reduce the likelihood of cross-contamination during priming.

As further shown by FIGS. **20** and **21**, those portions of loops **537** of trenches **523** not between print heads **128** (the outboard portions of loops **537**) extend on one side of layer **134** to the outside of layer **134**. As a result, layer **134** may be provided distant from pockets **142** and print heads **128** closer to an outer edge of flexible circuit **130** with a reduced likelihood of the adhesive paste material of layer **134** migrating or being squeezed too far to the outside. Since layer **134** is distant pockets **142** and print heads **128**, any inward migration of the adhesive paste material of layer **34** has little if any harmful results.

In the particular embodiment illustrated, trenches **523** have a width of between about 0.25 mm and about 2 mm (nominally about 0.5 mm) and a depth of between about 0.25 mm and about 2 mm (nominally about 0.5 mm). In other embodiments, trenches **523** may have other widths or depths depending upon the anticipated extent overflow of adhesive paste material of layer **134** and available area of surface **158**. Moreover, in some embodiments, selected portions of trenches **523** may have varying dimensions. For example, portions of trenches **523** between print heads **128** may have a reduced width and increased depth as compared to other portions of trenches **523** not between print heads **128**, permitting print heads **128** to be closer to one another.

In other embodiments, trenches **523** may have other patterns and configurations. In other embodiments where solidified adhesive paste layer **134** extends in close proximity to pockets **142** and print heads **128**, trenches **523** may alternatively extend on the inside edge of layer **134** between layer **134** and moats **143** so as to prevent inward migration of the adhesive paste material of layer **134**, prior to solidification or curing, towards print heads **128**. Although trenches **523** are illustrated as being continuous, in other embodiments, trenches **523** may be intermittently located along one or both edges of layer **134** while still providing some degree of containment for the adhesive paste material of layer **134**.

FIGS. **22-24** illustrate printing device **620**, another embodiment of printing devices **20** and **120**. Printing device **620** is similar to printing device **320** with solidified adhesive paste layer **134** having pattern **175** except that printing device **520** additionally includes impressions, grooves, channels or trenches **623**. Trenches **623** extend into surface **158** on both sides of layer **134**. Trenches **623** receive excess adhesive paste material of layer **134** as flexible circuit **130** and surface **158** are being pressed against one another prior to curing or solidification of the adhesive paste material of layer **134**. As a result, trenches **623** serve to contain the extent to which the adhesive paste material may migrate along surface **158** prior to solidification. Trenches **623** further receive excess adhesive paste material, reducing unevenness of flexible circuit **130** and enhancing the degree of flatness of flexible circuit **130** to potentially improve the ability of priming device **22** (shown in FIG. **1**) to form a seal against flexible circuit **130**.

In the example illustrated, trenches **623** form two distinct interior loops **637**A and **637**B (collectively referred to as loops **637**) extending about print heads **128**A and **128**B, respectively. Trenches **623** further include a continuous outer loop **639** that extends alongside and substantially parallel to a collective outer perimeter of loops **637**. Intermediate loops **637** are spaced from one another between print heads **128** to form an intermediate plateau, rib or landing **641**. Outer loop **639** is spaced from inner loops **637** to form an intermediate plateau, rib or landing **643**. In the embodiment illustrated, layer **134** is largely centered on landings **641** and **643**. As a result, layer **134** between print heads **128** is contained in both directions by trenches **623**. Thus, layer **134** may be provided in closer proximity to one or both print heads **128** between print heads **128** with a reduced likelihood of layer **134** interfering with or affecting the performance of print heads **128**. This allows print heads **128** to also be positioned closer to one another for a more compact design. At the same time, layer **134** continues to provide enhanced isolation between print heads **128** to reduce the likelihood of cross-contamination during priming. In addition, layer **134** may also be located closer to an outboard edge of flexible circuit **130** for enhanced sealing.

In the particular embodiment illustrated, trenches **623** of loops **637** have a width of between about 0.25 mm and about 2 mm (nominally about 0.5 mm) and a depth of between about 0.25 mm and about 2 mm (nominally about 0.5 mm). Trench **623** of loop **639** has a width of between about 0.25 mm and about 2 mm (nominally about 0.5 mm) and a depth of between about 0.25 mm and about 2 mm (nominally about 0.5 mm). In other embodiments, trenches **623** may have other widths or depths depending upon the anticipated extent overflow of adhesive paste material of layer numeral **134** and available area of surface **158**. Moreover, in some embodiments, selected portions of trenches **623** may have varying dimensions. For example, portions of trenches **623** between print heads **128** may have a reduced width and increased depth as compared to other portions of trenches **623** not between print heads **128**, permitting print heads **128** to be closer to one another.

Although the present disclosure has been described with reference to example embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the claimed subject matter. For example, although different example embodiments may have been described as including one or more features providing one or more benefits, it is contemplated that the described features may be interchanged with one another or alternatively be combined with one another in the described example embodiments or in other alternative embodiments. Because the technology of the present disclosure is relatively complex, not all changes in the technology are foreseeable. The present disclosure described with reference to the example embodiments and set forth in the following claims is manifestly intended to be as broad as possible. For example, unless specifically otherwise noted, the claims reciting a single particular element also encompass a plurality of such particular elements.

What is claimed is:

1. An apparatus comprising:

a fluid delivery system;

a first print head coupled to the fluid delivery system having nozzle openings and fluid passages leading to the nozzle openings;

a flexible circuit electrically connected to the first print head;

and a solidified adhesive paste layer sandwiched between the flexible circuit and the fluid delivery system, the nozzle openings of the first printhead extending on a first side of the solidified adhesive paste layer, and the flexible circuit extending on a second side of the solidified adhesive paste layer opposite the first side, wherein the solidified adhesive paste layer forms a hermetic seal between the flexible circuit and the fluid delivery system completely about and completely surrounding a perimeter of the first print head.

2. The apparatus of claim 1 further comprising a second print head, wherein the solidified adhesive paste layer forms a hermetic seal between the flexible circuit and the fluid delivery system at least partially about a perimeter of the second print head.

3. The apparatus of claim 2 further comprising a first trench extending into the fluid delivery system adjacent the solidified adhesive paste layer, wherein the solidified adhesive paste layer extends in at least portions of the trench.

4. The apparatus of claim 3, wherein the first trench extends between the first print head and the second print head.

5. The apparatus of claim 4 further comprising:

a second trench parallel to the first trench and between the first print head and the second print head; and

a landing between the first trench and the second trench, wherein the solidified adhesive paste layer extends on the landing.

6. The apparatus of claim 5, wherein the first trench extends below and along an edge of the solidified adhesive paste layer.

7. The apparatus of claim 3 further comprising:

a second trench parallel to the first trench and between the first print head and the second print head; and

a landing between the first trench and the second trench, wherein the solidified adhesive paste layer extends on the landing.

8. The apparatus of claim 7, wherein the first trench and the second trench extend about both the first print head and the second print head.

9. The apparatus of claim 2, wherein the solidified adhesive paste layer continuously extends entirely about the first print head and the second print head.

10. The apparatus of claim 2, wherein the solidified adhesive paste layer continuously extends between the first print head and the second print head.

11. The apparatus of claim 2, wherein the solidified adhesive paste layer includes:

a first loop continuously extending about the first print head; and

a second independent loop continuously extending about the second print head.

12. The apparatus of claim 2, wherein the solidified adhesive paste layer includes:

a loop continuously extending about both the first print head and the second print head; and

a segment continuously extending from a first side of the loop to a second opposite side of the loop between the first print head and the second print head.

13. The apparatus of claim 2, wherein the fluid delivery system includes a first pocket receiving the first print head and a second pocket receiving the second print head and wherein the apparatus further comprises a trench extending into the fluid delivery system adjacent the solidified adhesive paste layer and spaced from the first pocket and the second pocket.

14. The apparatus of claim 1, wherein the fluid delivery system includes a pocket receiving the first print head, wherein the apparatus further comprises a trench extending into the fluid delivery system adjacent the solidified adhesive paste layer and spaced from the pocket.

15. The apparatus of claim 1, wherein the adhesive paste layer is spaced from the first print head.

16. The apparatus of claim 15, wherein the fluid delivery system includes a pocket receiving the first print head and wherein the adhesive paste layer is spaced from the pocket.

17. A method comprising:

providing a print head having nozzle openings and fluid passages leading to the nozzle openings;

coupling the print head to a fluid delivery system;

providing a flexible circuit electrically connected to the to the first print head;

forming a layer of adhesive paste on one of the flexible circuit and the fluid delivery system; and

positioning the layer of adhesive paste against the other of the flexible circuit and the fluid delivery system to sandwich said layer of adhesive paste, such that the nozzle openings of the printhead extending on a first side of the solidified adhesive paste layer, and the flexible circuit extending on a second side of the solidified adhesive paste layer opposite the first side, the layer of adhesive paste extending completely about and completely surrounding a perimeter of the print head and spaced from the print head.

18. The method of claim 17, wherein the layer of adhesive paste is formed by treating a pre-form from a non-paste state to a paste state.

19. The method of claim 17, wherein the layer of adhesive paste is formed by ejecting a bead of viscous adhesive paste on one of the flexible circuit and the fluid delivery system.

20. The method of claim 17, wherein the layer of adhesive paste has a viscosity of less than or equal to about 200,000 centipoise during the forming of the layer on one of the flexible circuit and the fluid delivery system.

21. The method of claim 17, wherein the fluid delivery system includes a trench spaced from the print head and wherein positioning the layer of adhesive paste against the other of the flexible circuit in the fluid delivery system squeezes some of the adhesive paste into the trench.

22. The method of claim 17, wherein coupling the print head to the fluid delivery system comprises positioning the print head within a pocket and wherein the formed layer of adhesive paste is spaced from the pocket.

23. An apparatus comprising:

a fluid delivery system;

a first print head coupled to the fluid delivery system having fluid passages leading to nozzle openings;

a flexible circuit electrically connected to the first print head; and

a solidified adhesive paste layer sandwiched between the flexible circuit and the fluid delivery system, wherein the layer forms a hermetic seal between the flexible circuit and the fluid delivery system at least partially about a perimeter of the first print head;

a second print head, wherein the solidified adhesive paste layer forms a hermetic seal between the flexible circuit and the fluid delivery system at least partially about a perimeter of the second print head; and a first trench extending into the fluid delivery system adjacent the solidified adhesive paste layer, wherein the solidified adhesive paste layer extends in at least portions of the trench.

24. The apparatus of claim **23**, wherein the first trench extends between the first print head and the second print head.

25. The apparatus of claim **24** further comprising:

a second trench parallel to the first trench and between the first print head and the second print head; and

a landing between a first trench and the second trench, wherein the solidified adhesive paste layer extends on the landing.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,056,470 B2
APPLICATION NO. : 12/935023
DATED : June 16, 2015
INVENTOR(S) : Michael M. Marrow et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Claims
In column 12, lines 20-21, in Claim 17, delete "to the to the" and insert -- to the --, therefor.

Signed and Sealed this
Twenty-first Day of June, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office